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Summer Inventory of Mountain Goats And Stone's Sheep in the Nabesche River Drainage, North-eastern British Columbia, 1998

BC Hydro 

M. D. Wood
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The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

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1.0 INTRODUCTION

Mountain goats (*Oreamnos americanus*) reside in the Nabesche River drainage, north of the Peace Arm of Williston Reservoir, but no formal population surveys have been conducted to date. Population estimates, based on casual observations and reconnaissance-level aerial surveys, range between 40 and 100 animals; the majority of these goats reside in the Mt. Brewster area (J. Elliott, Ministry of Environment, Lands and Parks, personal communications; B. Culling, Diversified Environmental Services, pers. comm.; B. Churchill, Chillborne Environmental Consulting, personal communications). Approximately 60 goats were observed on the south end of the Mt. Brewster mountain complex during informal aerial surveys in 1977 (B. Culling, pers. comm.) and 1990 (B. Churchill, pers. comm.). Few goats or goat sign have been seen in the Mt. Burden/Mt. Greene areas west of Mt. Brewster, and goats have never been sighted on the ranges east of the Nabesche River and Emerslund Creek that are occupied by Stone's sheep (*Ovis dalli stonei*) (B. Culling, pers. comm.; B. Churchill, pers. comm.).

The restricted distribution of goats in the Nabesche drainage was suggested to be a result of a lack of natural mineral licks in the area (J. Elliott, pers. comm.). Goats rely heavily on mineral licks in the spring/summer period to replenish sodium reserves that are flushed from the body due to the intake of potassium-rich green forage (Hebert and McTaggart-Cowan, 1971). One major low elevation mineral lick complex (the "Brewster Lick") exists at the south end of Mt. Brewster, along a tributary to the Nabesche River. A primary access trail, worn down to mineral soil from years of consistent use, leads from the alpine range through the sub-boreal conifer forest to the heavily used mineral lick. A Wildlife Habitat Area (WHA) proposal for the Brewster Lick and its associated access trail was submitted to the provincial government by the PFWWCP in 1999. The 50 ha Brewster Lick WHA, approved in 2000, became one of the first WHA's to be established in the province of BC. No other goat mineral licks have been identified in the Nabesche River drainage.

This report documents the results of the July 1998 helicopter survey of mountain goats and Stone's sheep using alpine and subalpine summer habitats in the Nabesche River drainage, north of the Peace Arm of the Williston Reservoir. The primary objectives of the survey were to:

1. Determine the population size, demographics, and distribution of goats in the area.
2. Identify and georeference the locations of known and potential mineral licks.
3. Visually evaluate mountain goat habitat capability within the survey area.

Secondary objectives included estimating the population size, demographics, and distribution of Stone's sheep summering at high elevations throughout the survey area.

2.0 SURVEY AREA

The survey area encompassed 1,170 km² on the north side of the Peace Arm of the Williston Reservoir in north-eastern British Columbia (Figure 1). The survey area lies within the Misinchinka Ranges and Peace Foothills ecosections (Demarchi 1995).

The following synopsis of the area's geology was summarized from Irish (1970), Holland (1976), Thompson (1987), and Gadd (1995). A structural fault line situated east of Mt. Brewster (the "Brewster Fault") divides the Rocky Mountains' typical grey limestone Front Ranges in the west from the eastern Foothills. The Brewster Fault thrust more rugged cliff-forming Paleozoic formations in the west over Mesozoic shale and sandstone formations to the east. Folding and faulting of the limestone Front Ranges produced steep north-eastern and eastern faces, and gentle south-west facing slopes. Much farther west in the Main Ranges of the Rocky Mountains, strata primarily dip steeply to the south-west.

Biogeoclimatic subzones in the survey area include the wet cool Engelmann Spruce-Subalpine Fir (ESSFwk2) and the moist very cold ESSFmv4 between approximately 1,000 and 1,550 m elevation, and the Alpine Tundra (AT) zone above 1,550 m (DeLong et al. 1994, Ministry of Forests 1995). The ESSFwk2 exists west of Mt. Brewster and the West Nabesche River, and is wetter and warmer (with very high snow accumulations >3m) than the ESSFmv4 to the east and north of Mt. Brewster. High elevation bedrock outcrops on warm aspects within forested stands of subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) are typically used by goats in winter in the ESSFwk2 (DeLong et al 1994). In the ESSFmv4, steep shrub/grass habitat at higher elevations is frequented by Stone's sheep in summer, while goats use more rugged sites near escape terrain (DeLong et al 1994). Chinook winds (warm coastal winds flowing through the mountain passes into the valleys east of the Rocky Mountains) are common in the Peace Foothills ecosection east of the Nabesche River, and further reduce snow accumulations providing more hospitable conditions for wintering ungulates. In both subzones, avalanche chutes and moist subalpine sites provide forage for goats and sheep in spring and summer.

The survey area was delineated into 19 blocks, all within approximately 20-km of Mt. Brewster. The survey blocks lie between Bernard and Schooler Creeks, and included the mountains just north of the confluence of the Nabesche River and Emerslund Creek (Figure 2). Blocks ranged in size from 14 to 47 km² (mean = 29, SD = 8.4; Appendix A). All alpine and subalpine habitats in each block were surveyed, in addition to cliffs and rocky outcrops in the higher elevation ESSF forest.

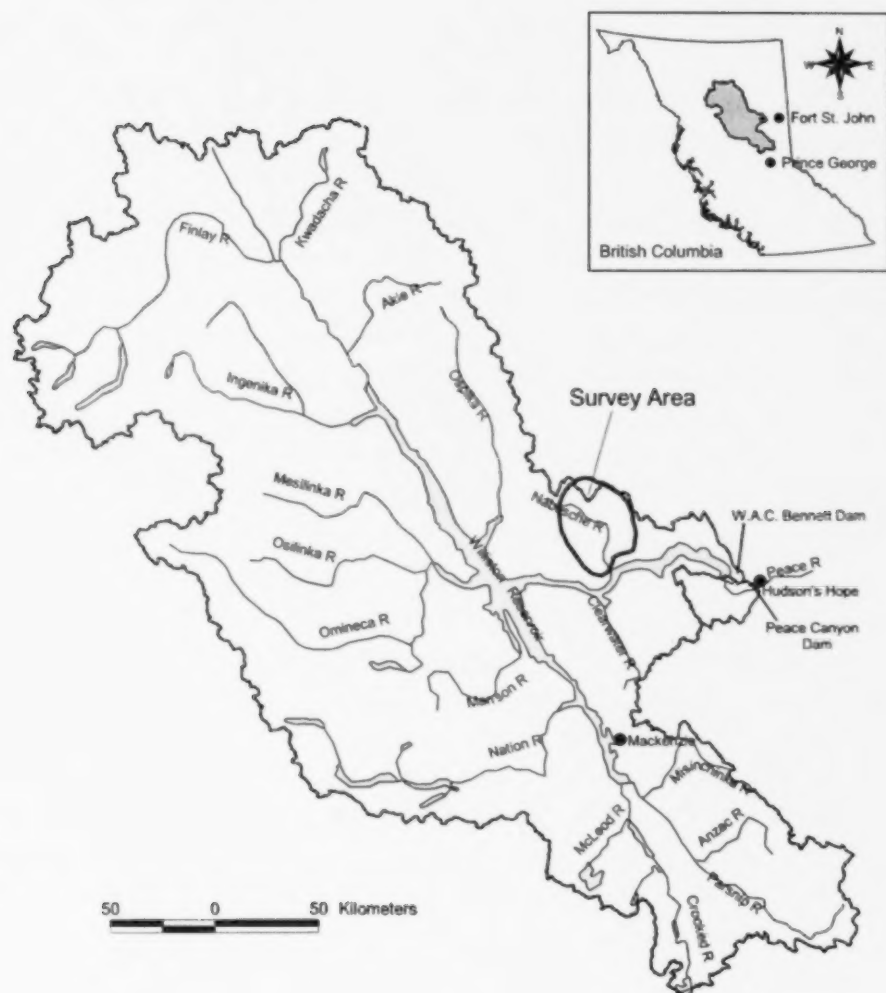


Figure 1. Survey area north of the Peace Arm of Williston Reservoir, north-eastern BC, 22-24 July 1998.

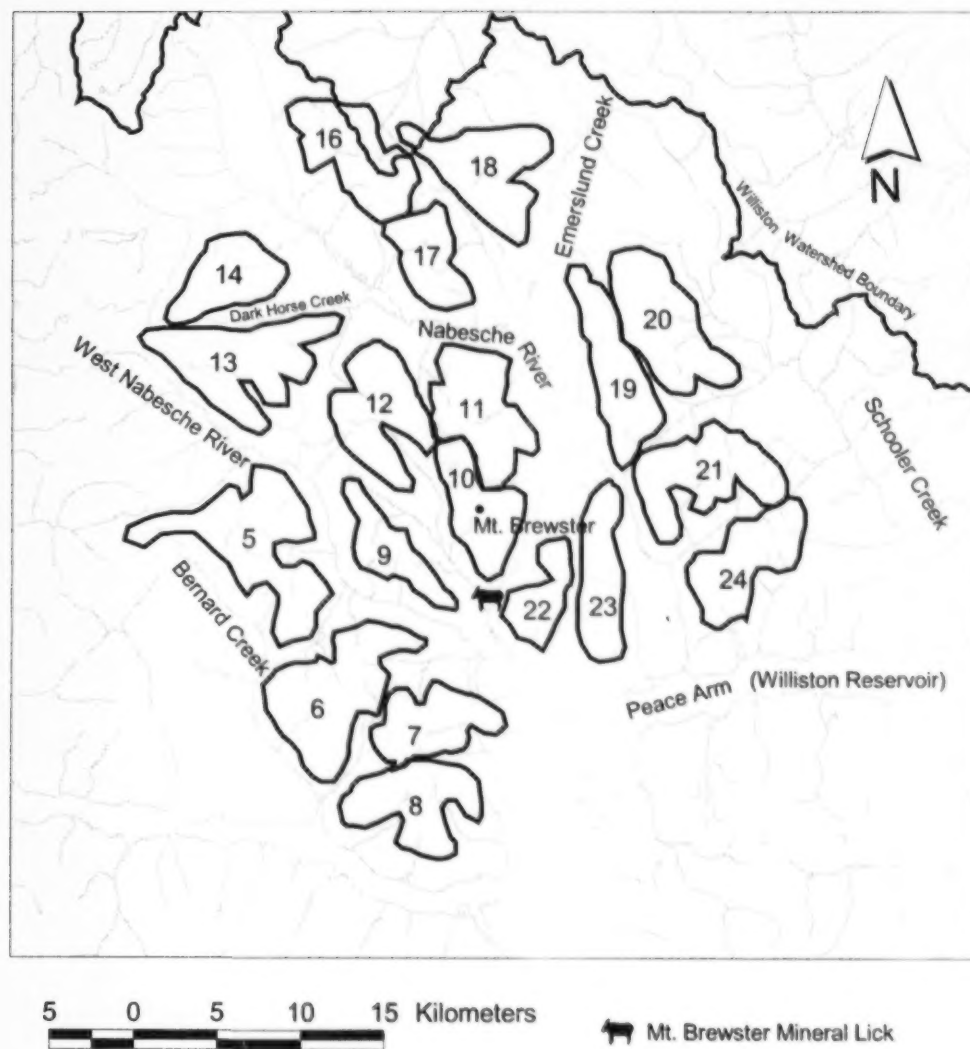


Figure 2. Mountain blocks surveyed in the Nabesche River drainage north of the Peace Arm of the Williston Reservoir, 22 - 24 July, 1998.

3.0 METHODS

We conducted the survey using a Bell 206 helicopter between 22 – 24 July 1998. The survey involved 14.2 hours of flying time (including ferry times between the survey area and Bear Valley logging camp). We followed standard provincial Resource Inventory Committee (RIC) methodology for total-count ungulate inventories (RIC 1997) which involved a thorough search of all alpine and subalpine areas in each block. No sightability correction factors were employed. Where the distance from the upper ESSF to the height of land was such that animals at either extreme could be missed, up to 4 parallel transects at increasing contour intervals were flown. The survey rate ranged between 0.2 - 1.5 min/km² on blocks where no ungulates were observed, to 1.3 - 2.1 min/km² where groups of animals requiring classification were located. Daytime temperatures remained consistent over the 3-day survey period at 15°-16°C and weather ranged from mostly sunny to mainly cloudy.

We recorded latitude/longitude co-ordinates for each group of animals located using the helicopter's on-board Global Positioning System (GPS) unit. Where multiple groups of animals were located within close proximity (e.g., <300 m apart), only one GPS location was obtained.

Mountain goats were classified to Level 3 RIC standards as adult (>2 years old) billies or nannies, yearlings (13 months), and kids (1 month), based on moult patterns, horns, presence of scrotal sac, and urination posture (RIC 1997, Smith 1988). In areas where >6 goats were observed in a group, or where classification from the air proved difficult, goats were classified from a nearby ground vantage point with spotting scopes. Stone's sheep were classified primarily on horn development and body size to Level 2 RIC standards as ewes/young rams (included adult ewes, Class I rams, and either sex yearlings), Class II rams, Class III rams, Class IV rams, and lambs (Geist 1971, RIC 1997). Woodland caribou (*Rangifer tarandus caribou*) were classified to Level 4 RIC standards as adult females, adult males (classes I, II, or III), and calves (RIC 1997). Males were distinguished from females based on antler size (for large males) and the absence of a black vulval patch.

Clay-banks or areas of exposed mineral soil observed during the survey that might provide sources of natural minerals were examined from the air for goat tracks or sign, and GPS locations were obtained. A visual assessment of the habitat in each mountain block was made from the helicopter and described into a handheld tape-recorder; much of the survey area was also recorded on a Sony Handy-Cam video recorder. The audio and visual habitat tapes were reviewed upon completion of the survey, and habitat was described and summarised by survey block.

4.0 RESULTS AND DISCUSSION

4.1 Mountain Goats

We observed 62 mountain goats during the July survey (Table 1, Figure 3). Goats were located in all 3 blocks of Mt. Brewster (Blocks 10, 11, 12), and in Block 13 in the upper Nabesche River drainage. The majority (66%) were found within Block 10 south of Mt. Brewster resulting in a density of 1.6 goats/km² for this block. Block 10 goats were in nursery groups comprised of nannies, young billies, yearlings, and kids (Table 1). Only adult billies were found in the 2 northern Mt. Brewster blocks: 1 billy (0.04 goats/km²) in Block 11, and 8 billies (0.21 goats/km²) in Block 12. The 12 goats (0.31 goats/km²) observed in Block 13 included 3 adult billies and 2 nursery groups. The overall mountain goat density for blocks where goats were observed (Blocks 10 - 13 combined) was 0.48 goats/km². Our observed densities are consistent with the 0.08 - 1.6 goats/km² (mean 0.46) reported by Hebert and Woods (1984) for the northern interior in the late 1970s and early 1980s. Most goats were found using steep alpine rocks or cliffs with slopes of 70-90%, or alpine grassland of more moderate slopes (30-40%) near escape terrain (Table 1). Groups G1 and G2 were sighted near the top of the forested ridge where the trail leads from the alpine down to the Brewster Lick.

We sighted 42 goats in the immediate vicinity of Mt. Brewster on this survey (groups G1 to G6), fewer than the previous sightings of approximately 60 goats seen during informal aerial surveys in 1977 (B. Culling, pers. comm.) and 1990 (B. Churchill, pers. comm). However, the discrepancy in numbers observed may be attributed to differences in sightability. Numbers of goats using alpine and subalpine habitats can be quite variable during summer months in areas where goats frequently travel through forested habitats to access low-elevation mineral licks. This was supported by our incidental sighting of approximately 20+ goats along the access trail that leads down to the Brewster Lick on 24 July at 14:17, after our official aerial survey was completed. Consequently, the 42 goats observed in the Mt. Brewster area, and 62 goats in the entire survey area, represent minimum population estimates only.

The observed ratio of 74 billies:100 nannies (Table 2) could range between 63:100 to 91:100 depending on the sex of the 4 unclassified adults (i.e., if all were females vs. all were males respectively). All 4 unclassified adults were located in nursery groups, thus it is most likely they were females. Likewise, the observed proportion of billies in the adult population (43%) could range between 39% and 48% depending on the sex of the additional 4 adult goats. The observed ratio of 48 kids:100 nannies could also decrease to 41:100 if all 4 unclassified goats were females.

The proportion of kids observed in the population (18%) is slightly lower than those reported for other interior mountain goat populations. Hebert and Woods (1984) reported an average of 21% kids from 19 surveys conducted throughout B.C. between 1975 and 1983. The proportion of kids in the population ranged between 20% - 29% for 5 of the 19 surveys which were conducted in the northern interior of the province. Hatler and Hazelwood (1985) observed 26% kids during studies of the Spatsizi Park goat population.

Table 1. Locations, habitat, and classifications¹ of mountain goat groups observed in the Nabesche River drainage, Peace Arm, Williston Reservoir, 22 - 24 July 1998.

Group #	Location	Block #	Elev (m)	Slope (%)	Aspect	Habitat	Adult			Yr	K	Total
							M	F	UC			
G1	Brewster	10	1,400	30-40	SW	rock, dense conifer		1			1	2
G2	Brewster	10		80	NW	rock, avalanche		1			1	2
G3	Brewster	10		40	W	alpine shrubland			2			2
G4	Brewster	10		30-40	SE	alpine shrubland		2		1	1	4
G5	Brewster	10		80	S	alpine rock, cliff	6	14	1	3	7	31
G6	Brewster	11		5		alpine heath	1					1
G7	Brewster	12		30-40	W	alpine heath, rock	4					4
G8	Brewster	12		70	N	alpine cliff	2					2
G9	Brewster	12		90	SW	alpine cliff	2					2
<i>Subtotal</i>							15	18	3	4	10	50
G10	Dark Horse	13		70	N	alpine rock	2	1				3
G11	Dark Horse	13		80	E	alpine cliff, talus		1				1
G12	Dark Horse	13		80	ENE	alpine cliff		1		1		2
G13	Dark Horse	13		80	ENE	rock/cliff, conifer		2	1	2	1	6
<i>Subtotal</i>							2	5	1	3	1	12
<i>TOTAL</i>							17	23	4	7	11	62

¹Ad (adult); Yr (yearling ~13 months); K (kid ~1 month), M (male), F (female), UC (unclassified)

Table 2. Sex and age composition of mountain goats observed during the Nabesche River drainage survey, 22 - 24 July 1998.

Billies/100 Nannies ¹	Proportion of billies in adult population ¹	Kids/100 Nannies ^{1,3}	Kids/100 Adults ^{2,3}	Proportion of kids in the population ^{2,4}	Yrlgs/100 Adults ²	Proportion of yrlgs in the population ^{2,5}
74:100	43%	48:100	25:100	18%	16:100	11%

¹ Excludes the 4 UC adults; ² Includes the 4 UC adults; ³ Excludes yearlings; ⁴ Includes yearlings; ⁵ Includes kids

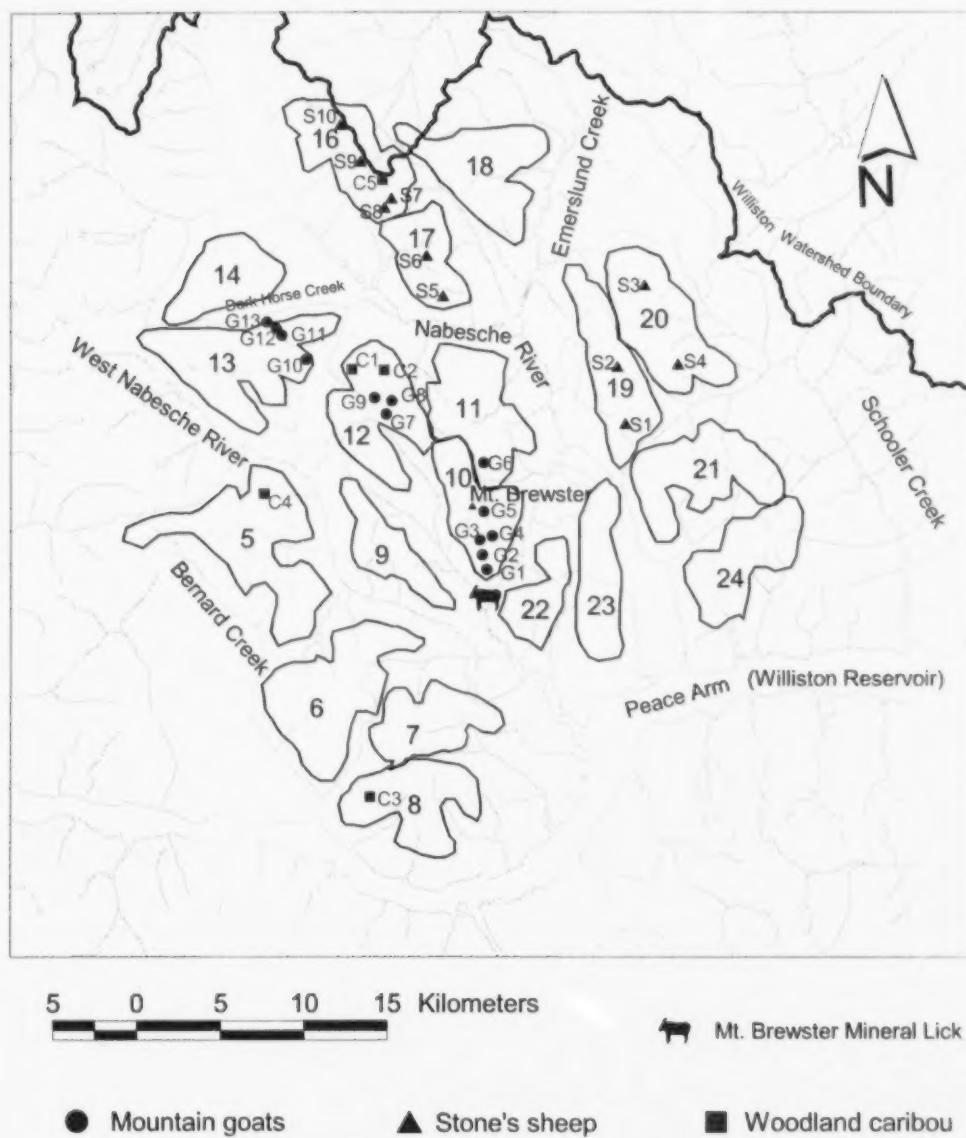


Figure 3. Locations of mountain goat (G), Stone's sheep (S), and woodland caribou (C) groups observed in the Nabesche River drainage, 22 - 24 July 1998.

4.2 Stone's Sheep and Other Ungulates

Numbers of Stone's sheep and other ungulates observed during the 3-day survey included 42 Stone's sheep (Table 3, Figure 3), 5 woodland caribou (2 cows, 1 Class I bull, 1 Class II bull, and 1 Class III bull; Figure 3), and 4 moose (1 bull, 1 unclassified adult, and a cow and calf). Stone's sheep were observed only in the northern and eastern blocks of the survey area. Sheep densities were highest Blocks 16 and 17 north of the confluence of the Nabesche River and Emerslund Creek (0.37 and 0.35 sheep/km² respectively), and lowest in Blocks 19 and 20 between the Nabesche River and Schooler Creek (0.24 and 0.23 sheep/km² respectively). Groups of mature rams were isolated from nursery groups of ewes, young rams, yearlings, and lambs, with the exception of one Class III ram that accompanied a nursery group in Block 19 (group S2; Table 3). Stone's sheep were found using primarily moderately-sloped (40-50%) alpine grassland and talus/scree habitats. The ratio of lambs:100 adults (includes all sheep >1 year old) was 15:100; the proportion of lambs in the population was 13%.

Table 3. Locations, habitat, and classifications¹ of Stone's sheep groups observed in the Nabesche River drainage north of the Peace Arm of the Williston Reservoir, 22-24 July 1998.

Group #	Location	Block #	Elev (m)	Slope (%)	Aspect	Habitat	II	III	IV	E	UC	L	Total
S1	W.Schooler	19		50	SSE	Draw, alpine mead.				3			3
S2	W.Schooler	19		70-80	NE	alpine grass; talus		1		4		2	7
S3	W.Schooler	20		0	-	alpine grassland		4	1				5
S4	W.Schooler	20		20-30	SSE	alpine grass; heath				6		1	7
<i>Subtotal</i>							0	5	1	13	0	3	22
S5	W.Emerslund	17		50	SSE	Alpine talus				4		3	7
S6	W.Emerslund	17		0	-	Alpine heath				1			1
S7	W.Emerslund	16		40	E	Alpine talus				2			2
S8	W.Emerslund	16		40-50	E	Alpine talus, scree					8		8
S9	W.Emerslund	16		60-70	W	Alpine shrub, talus		3	1				4
S10	W.Emerslund	16		40	W	Alpine talus				2			2
<i>Subtotal</i>							0	3	1	9	8	3	24
<i>TOTAL</i>							0	8	2	22	8	6	46

¹ II (Class II ram), III (Class III ram), IV (Class IV ram), E (adult ewes, yearlings, Class I rams), UC (unclassified adult), L (lamb ~2 months)

4.3 Habitat Assessment

Habitat descriptions for surveyed blocks and assessments of their capability to support goats and/or sheep are summarized below:

Forested Areas (Blocks 9, 21, 22, 23, 24):

These blocks lie below 1,500 m and are primarily forested with little or no escape terrain present. Rocky bluffs running along the west side of Block 23 are occasionally used by Stone's sheep (PFWWCP, unpublished data). No goats or sheep were seen during the survey, and no suitable habitat appears to exist for goats.

Mt. Brewster (Blocks 10, 11, 12):

A complex of rocky outcrops and cliffs interspersed with timber in the south-east portion of Block 10 provides excellent summer and winter goat habitat. These 3 blocks offer excellent high elevation summer goat range with abundant forage and escape terrain. These blocks accounted for 81% of the goats observed on the survey.

Mt. Greene/Mt. Burden/Dark Horse Creek (Blocks 5, 6, 7, 8, 13, 14):

These blocks are characterized by strongly linear topography, with many areas of vertical rock strata. Sheer cliffs hundreds of metres high with unvegetated scree slopes at their bases face north-east; south-west slopes are gentle and rounded. Deep snows are apparent as evidenced by the abundant snow patches still remaining in late July; little forage was observed in many places. No forested rocky outcrops or cliffs were observed with the exception of the eastern ridges of Block 13 where 12 goats were observed on the survey. The blocks west of Mt. Brewster appear to offer low to moderate summer habitat suitability for goats. Suitable winter habitat also appears to be lacking due to the apparent deep snow load, and the north-east facing direction of most of the steep escape terrain. Harper (1982) noted that while suitable terrain for mountain goats exists in these blocks, the deep snows reduce the habitat capability to 4W (Class 4 winter range on a scale of 1 Good to 6 Poor).

Upper Nabesche River (Blocks 16, 17, 18):

Blocks 16 and 17 likely offer suitable escape terrain and forage for goats, however, only Stone's sheep were observed on these blocks during the survey. No rocky outcrops or forested bluffs that could provide good winter goat habitat were observed though. These blocks appear to offer good year-round Stone's sheep range. There was no suitable escape terrain for either goats or sheep on the gently rounded terrain in Block 18.

Upper Schooler Creek (Blocks 19, 20):

These blocks consist of gentle mountainous terrain with abundant scree/talus slopes and plentiful forage. Some cliff habitat was noted, but significant suitable escape terrain for goats was lacking. These blocks lie to the east of the Brewster Fault in the Rocky Mountain Foothills. This area was only occupied by Stone's sheep during the survey, and likely offers excellent summer sheep habitat.

No new mineral licks were confirmed during the aerial survey (i.e., no goats or other visible signs of use present). Potential mineral licks (clay banks or areas of exposed mineral soil) were noted within or adjacent to Blocks 5, 6, 10, 11, 12, and 17. These sites, however, require a ground assessment to verify their status.

The Mt. Brewster area appears to provide the best habitat for goats within the survey area: a mix of suitable summer and winter escape terrain and forage, with a large mineral lick in close proximity. This area is geologically distinct from the remainder of the survey area. Two major fault lines exist within the survey area (the Brewster and Burden Faults), between which lie the Prophet and Stoddart geological formations (Irish 1970; Thompson 1987) (Figure 4). The Prophet Formation includes most of the Mt. Brewster complex; small portions of this formation also occur west of the Burden Fault on the east side of Mt. Greene and on the ridge just northeast of Mt. Burden (Irish 1970). Although comprised of limestone, dolomite and chert, the distinguishing characteristic of the Prophet Formation is its large chert content (up to 70%) (Irish 1970; Thompson 1987). All 62 mountain goats observed during the survey were located within the Prophet Formation that is situated between the 2 major fault lines (Figure 4). In summary, it appears that mountain goats have colonized the most suitable habitat within the survey area, and are well established in these areas.

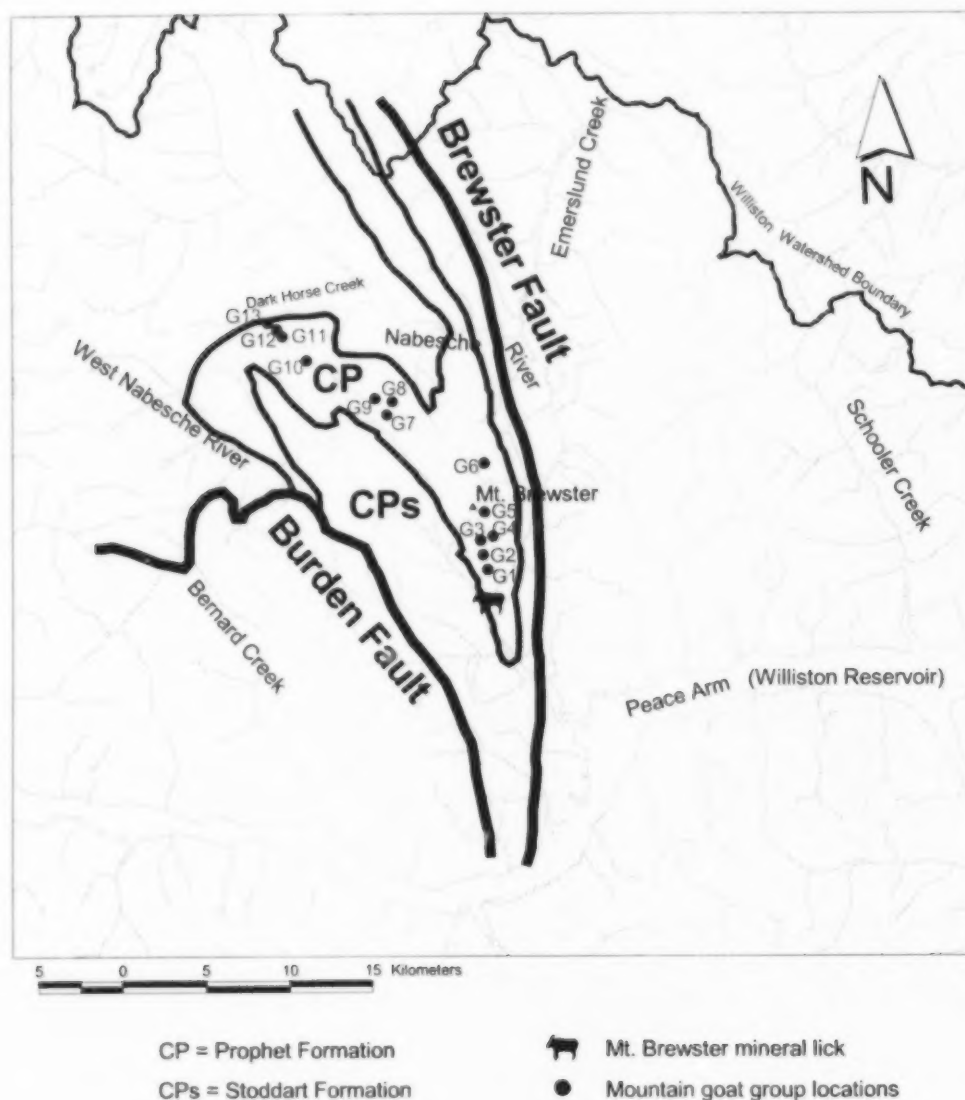


Figure 4. Location of Burden and Brewster fault lines, and Prophet and Stoddart geological formations within the Nabesche River watershed, north-eastern BC.

5.0 LITERATURE CITED

- DeLong, C., D. Tanner, and M.J. Jull. 1994. A field guide for site identification and interpretation for the Northern Rockies portion of the Prince George Forest Region. Ministry of Forests Land Management Handbook Number 29. Ministry of Forests, Prince George, BC. 141 pp.
- Demarchi, D.A. 1995. Ecoregions of British Columbia. Fourth Edition. 1:2,000,000 Mapsheet. Ministry of Environment, Lands, and Parks, Victoria, BC.
- Gadd, Ben. 1995. Handbook of the Canadian Rockies. 2nd Edition. Corax Press, Jasper, Alberta. 831 pp.
- Harper, F. 1982. Phase 1: Regional Wildlife Plan, South Peace River Sub-Region. Ministry of Environment, Lands, and Parks. Fort St. John, B.C.
- Hatler, D.F. and W.G. Hazelwood. 1985. Mountain goat surveys in the Tatlatui, Spatsizi and Mt. Edziza Provincial Park areas, British Columbia, July 1985. Unpublished report, BC Ministry of Lands, Parks, and Housing, Victoria, BC. 97 pp.
- Hebert, D.M. and I. McTaggart-Cowan. 1971. Natural salt licks as a part of the ecology of the mountain goat. *Can. J. Zool.* 49: 605-610.
- Hebert, D.M. and R. Woods. 1984. A preliminary analysis of intensive unreplicated survey data for mountain goat populations in British Columbia. *Proc. Fourth Bien. Symp. North. Wild Sheep and Goat Counc.* 4:506-516.
- Holland, S.S. 1976. Landforms of British Columbia: A physiographic outline. Bulletin 48. B.C. Department of Mines and Petroleum Resources, Victoria, BC. 138 pp.
- Irish, E.J.W. 1970. Halfway River Map-Area, BC (94B). Geological Survey of Canada Paper 69-11. Dept. of Energy, Mines, and Resources, Ottawa, Canada.
- Ministry of Forests. 1995. Biogeoclimatic zone map coverage for the Mackenzie Forest District. Ministry of Forests, Prince George, BC.

- RIC (Resources Inventory Committee). 1997. Standardized inventory methodologies for components of British Columbia's biodiversity: Aerial based inventory techniques for selected ungulates. Version 1.1. Resources Inventory Committee, Ministry of Environment, Lands, and Parks, Victoria, BC.
- Smith, B.L. 1988. Criteria for determining age and sex of American mountain goats in the field. *J. Mamm.* 69(2): 395-402.
- Thompson, R.I. 1987. Geology of Halfway River (94B). 1:250,000 Mapsheet. Map 1634A. Geological Survey of Canada. Vancouver, BC.
- Woodsworth, G.J. 1988. UTM conversion program. Geological Survey of Canada.

APPENDIX A

Area of mountain blocks surveyed:

Block No.	Area (km ²)	Date Surveyed	Survey Time (minutes)	Time/km ²
5	47	23 July	43	0.9 min
6	42	23 July	61	1.5 min
7	21	23 July	29	1.4 min
8	32	23 July	45	1.4 min
9	19	24 July	9	0.5 min
10	25	22 July	110	2.1 min
11	27	22 July		
12	38	22 July	52	1.4 min
13	39	23 July	85	1.3 min
14	25	23 July		
16	27	24 July	80	2.0 min
17	14	24 July		
18	26	24 July	22	0.8 min
19	26	22 July	34	1.3 min
20	33	22 July	52	1.6 min
21	31	24 July	19	0.6 min
22	16	22 July	7	0.4 min
23	34	22 July	12	0.4 min
24	29	24 July	5	0.2 min
TOTAL	551		665	1.2 min

